UNPUBLISHED PRELIMINARY DATA

UNIVERSITY OF DENVER Denver Research Institute

COLORADO SEMINARY University Park, Denver 10, Colorado

19 December 1963 N64-25574

3p. CODE-1 CAT. 18

NASA CR-56907

National Aeronautics and Space Administration
1520 H Street N. W.
Washington 25, D. C.

Attention: Office of Grants and Research Contracts, Code SC

Gentlemen:

This letter is a report of progress on Research Grant NsG-365 entitled "Theoretical Studies on the Relationships Between ~~the~~ Thermionic Work Function of Refractory Intermetallic Compounds and Their Electronic and Crystal Structures", for the period 1 July 1963 to 31 December 1963.

1.0 Introduction

All of the group VI-A metals form intermetallic compounds with rhenium. In the chromium-rhenium system, a single σ-compound is observed at about 85 w/o Re. Similar compounds are also observed in the molybdenum-rhenium and tungsten-rhenium systems.[1,2] An additional compound having the α-Mn structure is present in the molybdenum-rhenium and tungsten-rhenium systems. It is the objective of the present study to measure the thermionic work functions of the five compounds and determine how they are related to the electronic and crystal structures.

2.0 Metallurgical Studies

During the report period, arc melting and heat-treating techniques were developed in order to obtain the required single phase specimens. The following table indicates the compositions of four of the compounds and the heat treatments necessary to obtain single-phase specimens from the arc-cast materials.

1 Dickinson, J. M. and Richardson, L. S., ASM Trans. 51, 1055, (1959).
2 Dickinson, J. M. and Richardson, L. S., ASM Trans. 51, 758, (1959).

OTS PRICE

XEROX $ 1.10 ph

System	Phase	Composition (Wt. percent)	Heat Treatment
Mo-Re	σ	29Mo - 71Re	2300°C - 3/4 hr
	x	15Mo - 85Re	1850°C - 4 hrs
W-Re	σ	45W - 55Re	2300°C - 3/4 hr
	x	27W - 73Re	1850°C - 4 hrs

3.0 Sample Fabrication

Several methods of specimen fabrication were investigated during the report period. A review of the literature at the beginning of the research program indicated that the specimens should be wire-like with length-to-diameter ratios of about 100 in order to eliminate electric-field and thermal end effects. One of the most promising methods investigated was a technique whereby an evacuated quartz capillary is plunged into the molten material in the arc melting operation. Using this method, it was possible to cast 3 mm diameter specimens up to 3 inches in length. Although specimens of about this size have been used to measure thermionic properties,[3] the 3 mm diameter would permit only indirect heating of the emitter material. Heat transfer calculations would then dictate the use of a metal diode envelope, possibly water cooled, with the attendant high power requirements, in order to obtain emitter temperatures of about 1500°C. Attempts to reduce the diameter by using smaller diameter quartz capillaries were unsuccessful. The already small diameter and the brittle nature of the refractory intermetallic compounds also precluded a drawing or centerless grinding operation.

Power metallurgy techniques which had been initiated at the time of the last report were rejected for the same reason.

Levi and Esperson[4] developed a process for electroplating rhenium on tungsten wires, but observed no appreciable interdiffusion at temperatures as high as 2850°C, therefore electroplating procedures were rejected.

Present thinking is directed toward two alternate techniques, namely an electropolishing process utilizing 2% NaOH solution and high-current density or electrophoretic deposition of the finely ground intermetallic compounds on 10-mil tungsten wire. The smaller diameter specimens can be heated directly by resistance, and permit the use of a sealed glass diode envelope.

---

3 Lafferty, J. M., J. Appl. Phys. 22, 299, (1951).

4 Levi, R. and Esperson, G. A., Phys. Rev. 78, 231, (1950).

Such a diode eliminates the considerable experimental difficulty of maintaining an active vacuum in the 10^{-9} to 10^{-10} Torr region. The sealed glass diodes are fitted with an internal nude ion gage, which also functions as a vacuum pump when in operation.

4.0 Thermionic Measurements and Data Reduction

Thermionic work function measurements will be made using a high-voltage pulsing system similar to that developed by Haas[5] and used successfully for several years by his group. This device produces 20 μsec, 60 cycle pulses of up to 15 KV. Current and voltage are displayed on a Tektronix 535A oscilloscope.

Schottky plots of log (current density) vs. $(\text{field})^{\frac{1}{2}}$ will be produced for each temperature at which measurements are made, and the linear portion of the curve extrapolated to zero field. The zero field values will then be used to construct Richardson plots of log j/T^2 vs. $1/T$ in order to obtain the work function and the Richardson constant, A_R.

Accurate temperature measurements are required, and will be obtained by using a calibrated optical pyrometer. Emissivity data are not available, but will be determined experimentally using the Worthing-tube method.

Respectfully submitted,

C. Samuel Miller

C. Samuel Miller
Graduate Research Associate

Jerry D. Plunkett

Jerry D. Plunkett
Project Supervisor

5 Haas, G. A., and Harris, F. H., Rev. Sci. Instr. 30, 623, (1959).